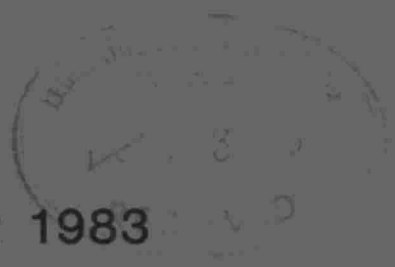
AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY



Annual Report 1983

Ontario
Ministry
of the
Environment

AMBIENT AIR QUALITY
IN
WINDSOR AND VICINITY

Annual Report 1983

Technical Support Section
Southwestern Region

ONTARIO MINISTRY OF THE ENVIRONMENT
October 1983

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SUMMARY

The Ministry's air quality monitoring program conducted in the Windsor area revealed satisfactory air quality with respect to many air pollutants and appreciable improvement in suspended particulate levels in 1983 compared to previous years.

Despite the improvement in suspended particulate levels there are occasions when levels are excessive. The excessive levels were experienced most frequently at monitoring station 12013 which is affected by emissions from the casting plant of Ford Motor Company of Canada, Limited. A considerable amount of pollution control equipment has been installed at the casting plant and more is planned.

Malodours in west Windsor are in part attributable to ambient levels of total reduced sulphur compounds emitted from the Zug Island area of Michigan. Levels of total reduced sulphurs monitored in west Windsor were marginally higher in 1983 than in 1982.

There were frequent excursions above the criterion established for ozone, the most abundant photochemical oxidant in ambient air. The elevated levels are partly a result of local emissions but to a greater degree are a result of the long-range transport of oxidants and precursor chemicals into the Windsor area. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop an appropriate control strategy. The U.S. Environmental Protection Agency is requiring individual states to implement oxidant control strategies by the end of 1987.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation or the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore, the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. The air monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

In the past, the Ministry has received a number of complaints about odours when winds have been blowing towards west Windsor from the general direction of Zug Island. For several weeks in 1981 and 1982 mobile air monitoring vans were deployed by the Ministry to attempt to identify the constituent or constituents in the ambient air causing the offensive odours. Unfortunately, meteorological conditions were not conducive to identifying the causes of the malodours. In 1983 samples of malodorous air were collected on adsorbent cartridges. However, the analytical results for the cartridge samples did not reveal what constituents were causing the malodours. Further sampling will be conducted in 1984.

The State of Michigan and the Province of Ontario regularly exchange information regarding ambient air quality and pollution abatement programs. This annual report deals specifically with ambient air quality in the Windsor area.

Detailed information on pollution abatement activities may be obtained from the Windsor District Office of the Ministry and the State of Michigan.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of existing historical stations is deemed adequate to evaluate the long-term trend in levels of pollutants.

Monitoring sites are distributed more densely in the downtown area where emissions from motor vehicles and commercial establishments are more prevalent and in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan. At the beginning of 1983, twenty-one dustfall monitoring sites were eliminated, leaving only 2 sites in operation. It is believed that the increase in suspended particulate monitoring during recent years makes most of the dustfall data superfluous.

In 1983, a new suspended particulate monitoring site was started in LaSalle, station number 12006. At station 12016 in west Windsor a dichotomous sampler was installed as part of a province-wide study of particulate matter. The dichotomous sampler collects suspended particulate matter in two size fractions. Coarse particulates are collected in the fraction with an upper cut-point of 10 microns (50% mass median diameter) and a lower cut-point of

2.5 microns (50% mass median diameter). Fine particulates are collected in the fraction with an upper cut-point of 2.5 microns (50% mass median diameter).

The locations of the Ministry's monitoring stations in the Windsor area are indicated on Figure 1 and are described in Table A1 of Appendix 1. Also shown in Figure 1 are the locations of 5 monitoring sites at which Ontario Hydro operates sulphur dioxide monitors. The sulphur dioxide monitors of Ontario Hydro are located in different directions from the J. C. Keith Generating Station at distances ranging from 5 to 7 kilometres.

The pollutants monitored at the various Ministry stations are indicated in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and prime factors supporting these criteria are contained in Appendix 1, Table A3.

METEOROLOGICAL DATA

Meteorological data for 1983 were obtained from station 12001 in west Windsor. Wind speed, wind direction and ambient temperature are measured continuously at 18 metres above ground level. At 80 metres above ground level the difference between the temperature at the 80-metre level and the 18-metre level is determined. Wind speed and direction are measured at the 80-metre level. The meteorological data are telemetred 12 times per hour to a computer of the Ministry in Toronto.

Meteorological data are correlated with other pollutants such as suspended particulates, sulphur dioxide and ozone to determine sources of pollutants. The data are also used to forecast dispersion conditions in association

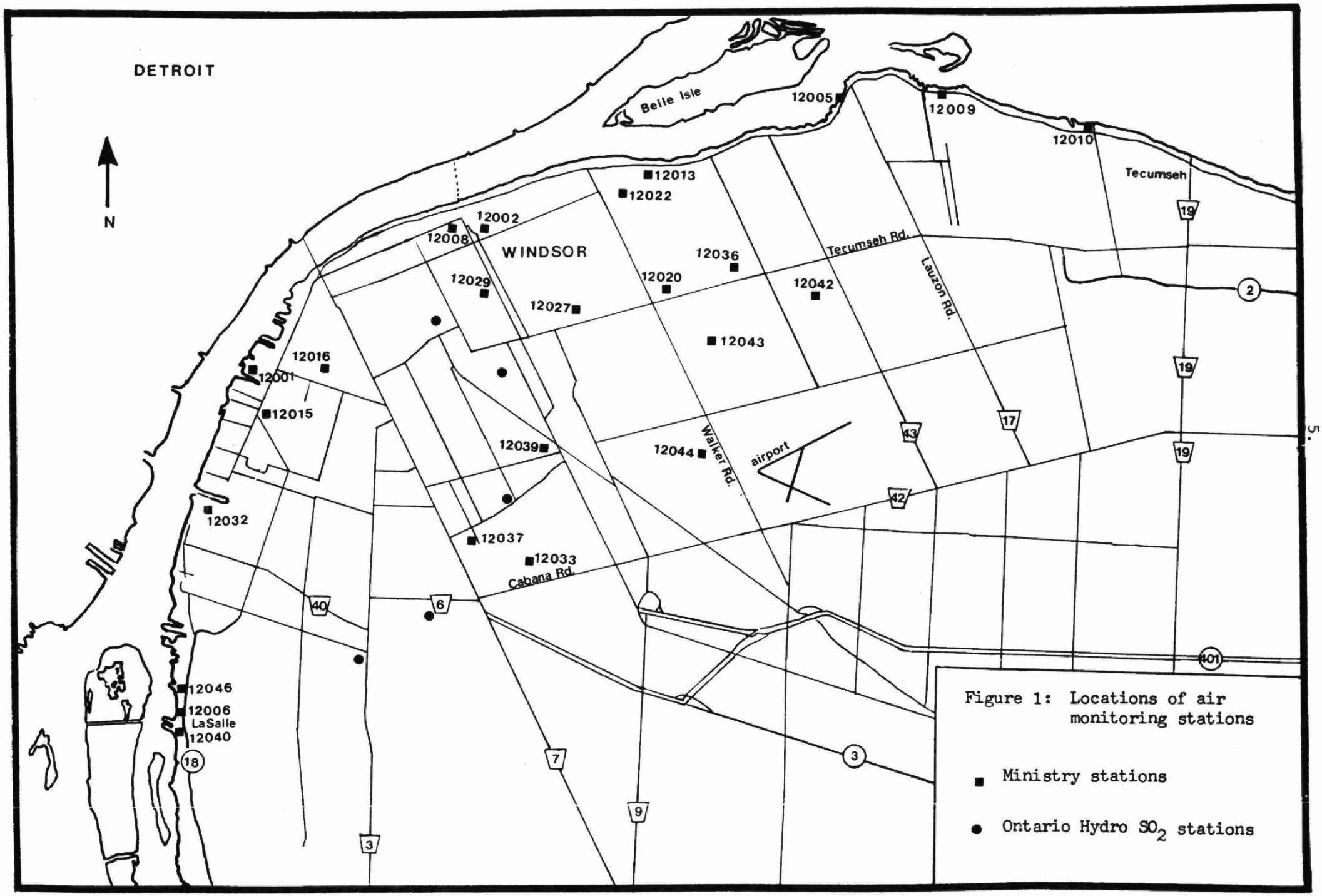


Figure 1: Locations of air monitoring stations

■ Ministry stations

● Ontario Hydro SO_2 stations

with the Air Pollution Index. During 1983 several problems arose which invalidated much of the meteorological data. On three occasions lightning damage to the upper-level aerovane resulted in erroneous data. Construction at the base of the tower resulted in the data for the 18-metre level being invalidated for essentially all of 1983. Consequently, there was insufficient meteorological data for 1983 to construct proper pollution roses.

MONITORING AND PROGRAM RESULTS

PARTICULATES

The iron and steel industry, foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that adversely affect air quality in Windsor. Wind-blown particulates from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates, dustfall and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter. To determine total suspended particulate concentrations a large volume of air is drawn through the filter using a Hi-Vol sampler. The dichotomous sampler at station 12016 is special in that it simultaneously collects particulates in a coarse size fraction and a fine size fraction. The coarse fraction contains particulates beteen 10 and 2.5 microns based on cut-points of 50 percent mass median diameters. The fine fraction contains particulates less than 2.5 microns. The majority of particulates inhaled by

humans are less than 10 microns in diameter but most particles greater than 2.5 microns are removed by the body's natural protection system.

Dustfall is measured by exposing an open cylinder (jar) of known diameter for 30 days and subsequently weighing the amount of particulates collected in the jar.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photoelectric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast with the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

Suspended Particulates

Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24 hour period. The other criterion is an annual geometric mean of 60 ug/m^3. The criterion for 24-hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

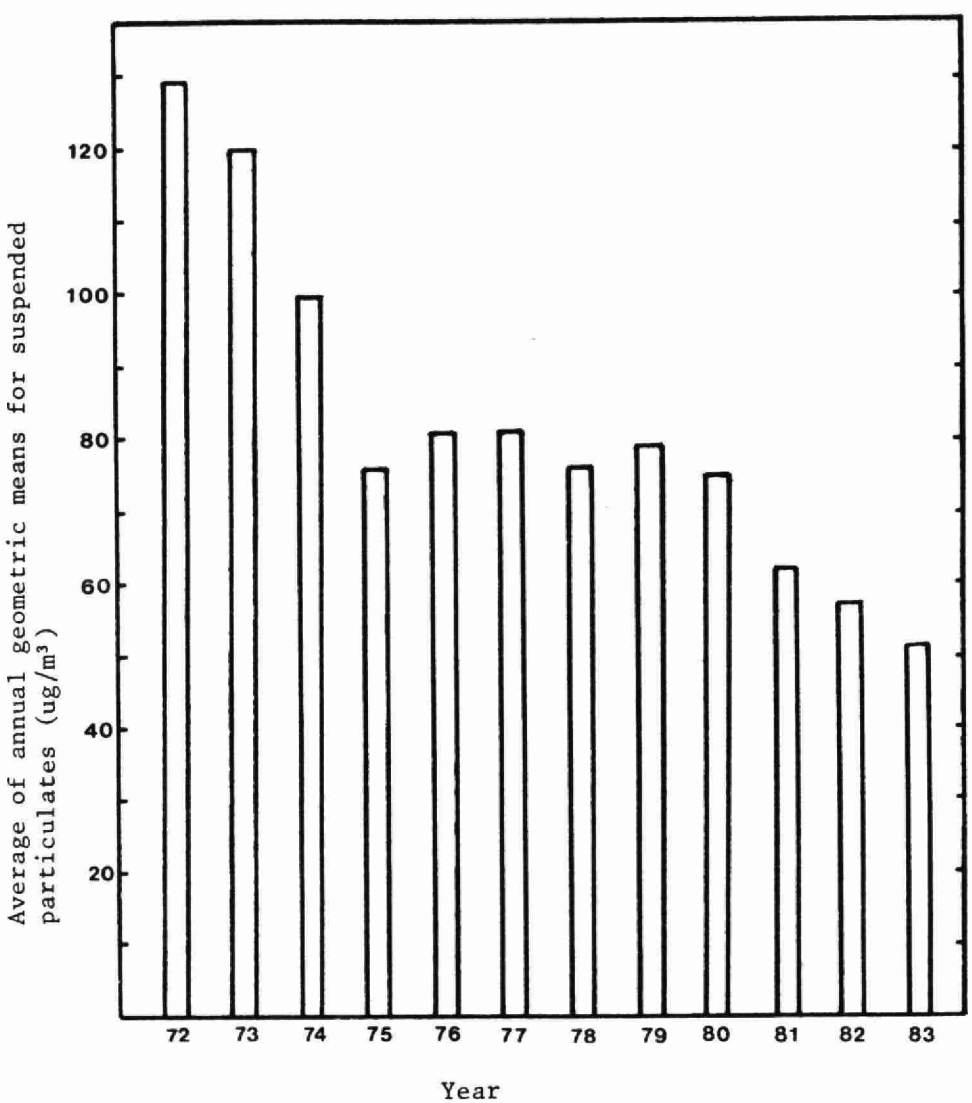
During 1983 filters were exposed to collect suspended particulate matter at 13 sites in the Windsor area. At all sites except stations 12008 and 12016 samples were collected on a frequency of every-sixth-day. At station 12008 sampling was conducted every day to provide information by which it could be determined if the every-sixth-day sampling schedule is representative of the whole year. At station 12016 the every-sixth-day schedule was used until September to collect samples of total suspended particulate matter using a Hi-Vol sampler. However, an every-sixth-day schedule was implemented in September for Hi-Vol samples and for fine and coarse particulates collected by a dichotomous sampler that was installed in September.

During 1983 the measured levels of total suspended particulate matter were appreciably lower than in previous years. The degree of improvement in total suspended particulate levels is illustrated in Figure 2 which shows the average of the annual geometric means and the average of the frequency of values above the 24-hour criterion for 7 monitoring stations in operation since 1972.

The improvement is further shown by the annual criterion for desirable ambient air quality being achieved at 11 of 13 monitoring sites in 1983 compared to 7 of 13 monitoring sites in 1982 and 6 and 4 sites in 1981 and 1980, respectively. A summary of the data for the monitoring stations in operation during 1983 is presented for the years 1972 through 1983 in Table 1.

At station 12013, located near the casting plant of Ford Motor Company of Canada, Limited, total suspended particulate levels for 1983 were marginally lower than 1982

Figure 2. Trend in levels of suspended particulates based on averaged data from seven monitoring stations.



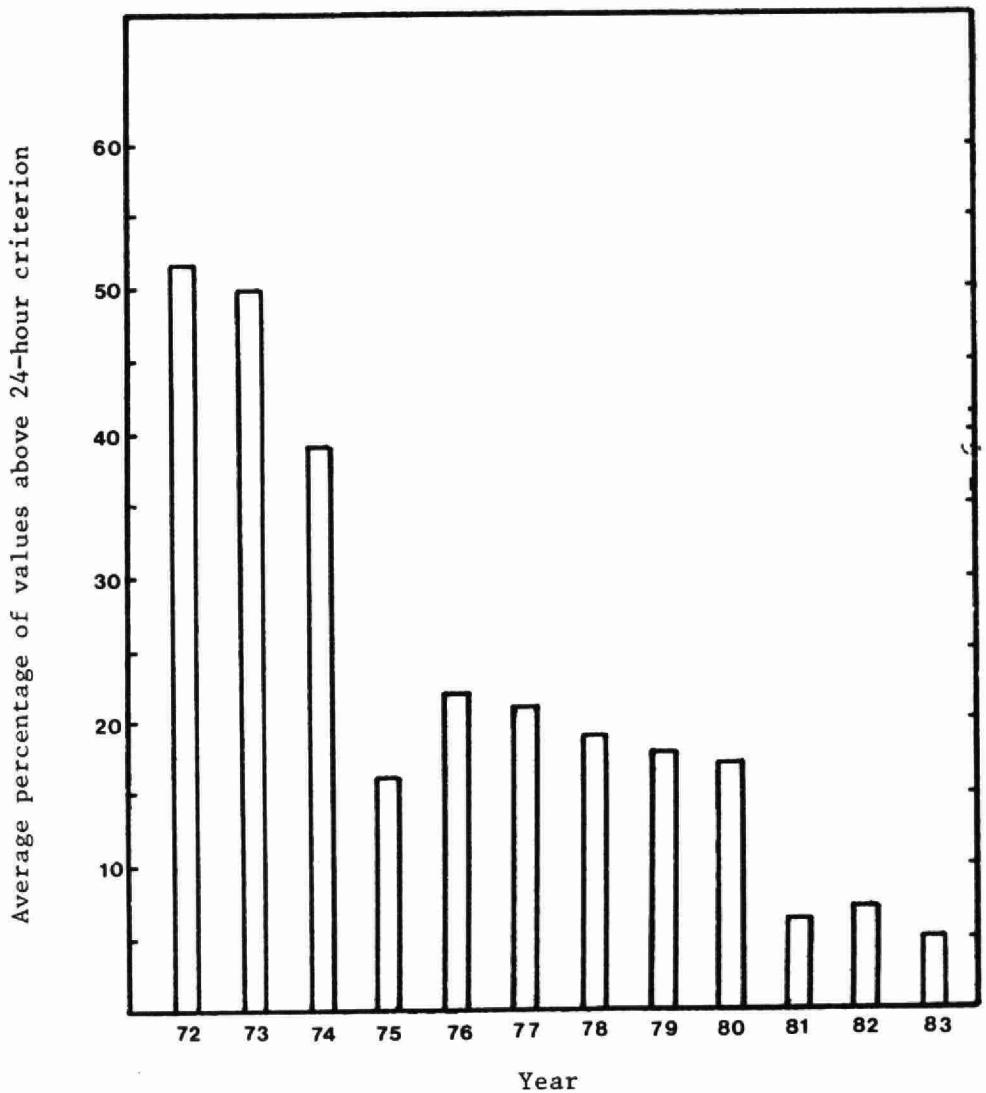


Table 1. Summary of data for total suspended particulates.

Station	Year											
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
	Annual geometric means (ug/m^3)											
12002	159	133	108	74	76	82	79	80	77	69	62	53
12005							I.D.	63	55	45	45	36
12006												49
12008	126	126	116	82	80	87	80	80	71	58	55	53
12008S											58	60
12009	79	82	61	52	58	54	52	57	58	46	46	36
12010	85	86	58	46	54	47	46	53	47	40	39	31
12013	151	145	113	89	98	113	100	98	75	65	68	65
12015	183	147	152	105	113	93	93	98	108	87	70	59
12016				88	88	95	84	85	83	67	63	50
12032	126	120	94	81	89	93	79	84	(88)	72	61	62
12036						72	63	72	70	55	53	49
12037						67	68	62	60	49	39	42
12039								79	71	71	53	49
	Percentage of values above 24-hour criterion											
12002	70	58	43	14	15	21	18	16	19	9	11	4
12005							4	4	2	2	2	0
12006												6
12008	57	55	47	17	19	24	16	17	12	6	4	2
12008S											4	4
12009	16	25	10	2	5	7	9	4	9	0	4	0
12010	23	27	17	2	10	6	7	0	0	0	0	0
12013	65	69	44	26	37	40	40	42	15	5	18	16
12015	80	66	84	33	42	25	27	33	46	16	8	3
12016				20	24	22	23	20	20	6	5	3
12032	53	53	30	21	27	25	19	16	(20)	7	5	7
12036						11	9	15	13	2	2	0
12037						10	15	2	2	2	2	0
12039								14	8	3	6	2

I.D. - Insufficient data to compute a representative geometric mean.

( ) - Annual geometric mean and percentage of values above 24-hour criterion based on data not representative of total year.

Data for station 12008S are every-sixth-day sampling results extracted from the daily sampling data for station 12008.

levels. This site had the highest frequency of excursions above the 24-hour criterion for desirable ambient air quality in both 1982 and 1983. It was also 1 of the 2 Windsor sites in 1983 that had an annual geometric mean concentration above the annual criterion for desirable ambient air quality.

Notwithstanding the higher levels experienced at station 12013 compared to levels at other monitoring stations in Windsor, levels of total suspended particulates have been much lower in recent years compared to levels experienced in the early 1970's. Ford Motor Company have continued to implement control programs for particulate emissions. Evaluation of emissions is continuing.

Levels of total suspended particulates tend to be higher in west Windsor, downtown Windsor and near the casting plant of Ford Motor Company than in east Windsor and areas further from the Detroit River. This is not surprising since west Windsor is close to emissions from the heavily industrialized area of Wayne County, downtown Windsor has appreciable emissions from traffic and combustion and the casting plant emissions require further reduction. Figure 3 illustrates the annual geometric mean concentrations and the percent frequencies of excursions above the 24-hour criterion at the approximate locations of the monitoring stations.

The daily sampling at station 12008 revealed that the every-sixth-day sampling schedule utilized for the other monitoring sites during 1983 would probably provide annual geometric means and frequencies of excursions above the

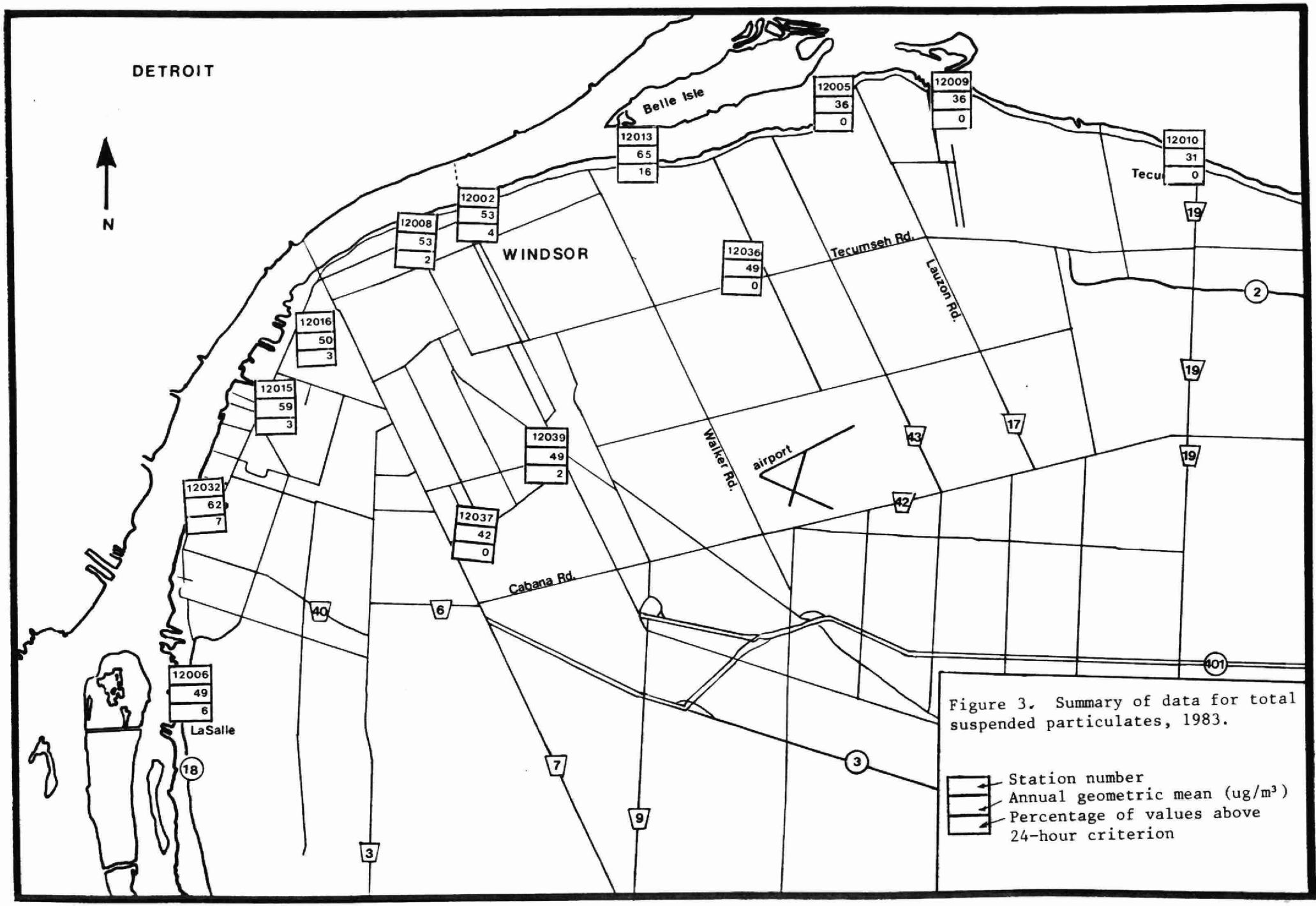


Figure 3. Summary of data for total suspended particulates, 1983.

24-hour criterion that are slightly greater than would have been obtained through daily sampling.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 6 stations in Windsor were analyzed quantitatively for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrates, sulphates and vanadium. In addition, samples were analyzed for fewer parameters for 4 additional monitoring stations. A summary of these data collected from 1976 through 1983 is presented in Appendix 2, Table A4. Data for sulphates are erroneously high based on the findings of several studies of the sampling method utilized by the Ministry. The Ministry has investigated different filter media which might provide more accurate sulphate results but have not found a filter medium that solves the sulphate problem without creating other problems. Copper results tend to be erroneously high because the vacuum pump that draws the air through the filter emits copper because of wear to the copper armature and these emissions can be drawn through the filter during certain meteorological conditions.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium (see Table A3). Concentrations of the various metals have been traditionally low with no values above the criteria.

Iron levels reported for station 12039 were higher than in 1981 and 1982 but appreciably lower than in 1978 through 1980. Station 12039 is located near the scrap metal recycling operation of Zalev Bros. Ltd. and occasionally iron levels are well above background indicating an impact on air quality at station 12039 from emissions by Zalev Bros. Ltd. However, only 1 of the 58 samples collected

during 1983 had a total suspended particulate concentration greater than the 24-hour criterion for desirable ambient air and the 1 excursion was not associated with an elevated iron level. Therefore, based on 1983 data, the emissions from Zalev Bros. Ltd. were detectable at station 12039 but not sufficient to create an unsatisfactory situation.

Station 12013 is located in the vicinity of the casting plant of Ford Motor Company of Canada, Limited. Although levels of iron, manganese and chromium are not unsatisfactory they are elevated above background at this station. Furthermore, total suspended particulate levels are unsatisfactory despite extensive improvements in pollution control at the casting plant. Additional controls are planned for the casting plant. The enrichment in ambient levels of iron, manganese and chromium coinciding with elevated levels of total suspended particulate matter may provide an indication of which sources of total suspended particulates should be further controlled.

Dustfall

The criteria for desirable ambient air quality established for dustfall are a 30-day loading of 7.0 grams of dustfall per square metre ($g/m^2/30$ days) and an annual average of 4.6 $g/m^2/30$ days. These criteria were established on the basis of historical data and standards developed by other regulatory agencies.

Measuring dustfall over a 30-day period is a very crude measurement subject to many interferences. As a result dustfall monitoring is being phased out in southwestern Ontario. During 1983 dustfall measurements were made at only 2 sites - stations 12040 and 12046 in the LaSalle area. These 2 sites will be terminated at the end of 1984 and the Hi-Vol sampler at station 12006 will be used

to determine particulate levels in the LaSalle area. At both stations 12040 and 12046 the annual criterion for desirable ambient air quality was exceeded. The 30-day criterion was exceeded by 1 of 9 samples collected at station 12040 and by 3 of 9 samples collected at station 12046. The 1983 dustfall values are listed in Table 2.

Table 2. Levels of dustfall during 1982

	Dustfall Loading ($g/m^2/30$ days)	
	Station 12040	Station 12046
January	3.9	3.6
February	2.9	4.1
March	5.9	--
April	6.2	9.3
May	4.8	4.6
June	7.2	7.7
July	--	--
August	6.9	--
September	--	7.1
October	--	4.9
November	4.2	3.8
December	2.2	1.8
Annual Average	4.9	5.2

Underlined values exceed desirable ambient air criteria.

SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power generating plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1983 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in suspended particulate matter. Data for sulphate in suspended particulates are presented in Table A4 supporting the section on the Chemical Analysis of Suspended Particulates.

Sulphur Dioxide

The criteria for desirable ambient air quality with respect to sulphur dioxide are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

During 1983 gaseous sulphur dioxide was measured continuously by the Ministry of the Environment at four fixed locations in Windsor. The monitoring locations are shown on Figure 1 as stations 12008, 12013, 12016 and 12032. The monitors are continuous fluorescence-type instruments. None of the desirable ambient air quality criteria were exceeded at any of the monitoring stations during 1983. A summary of the 1983 data is presented.

Table 3. Summary of 1983 data for sulphur dioxide

Parameter	Station number 12008	12013	12016	12032
Annual average (ppm)	0.01	0.01	0.01	0.01
Percentage of values greater than:				
1-hour criterion	0	0	0	0
24-hour criterion	0	0	0	0
Highest 1-hr value (ppm)	0.17	0.10	0.22	0.15
Highest 24-hr value (ppm)	0.04	0.04	0.04	0.03

In recent years levels of sulphur dioxide have been satisfactory and appreciably lower than the levels experienced in the early 1970's. The improvement is illustrated in Figure 4 which shows the frequencies of excursions above the 1-hour and 24-hour criteria for sulphur dioxide as measured at stations 12008 and 12032. The improved air quality is attributable to better control and dispersion of emissions of sulphur dioxide in Wayne County, Michigan and Windsor.

AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

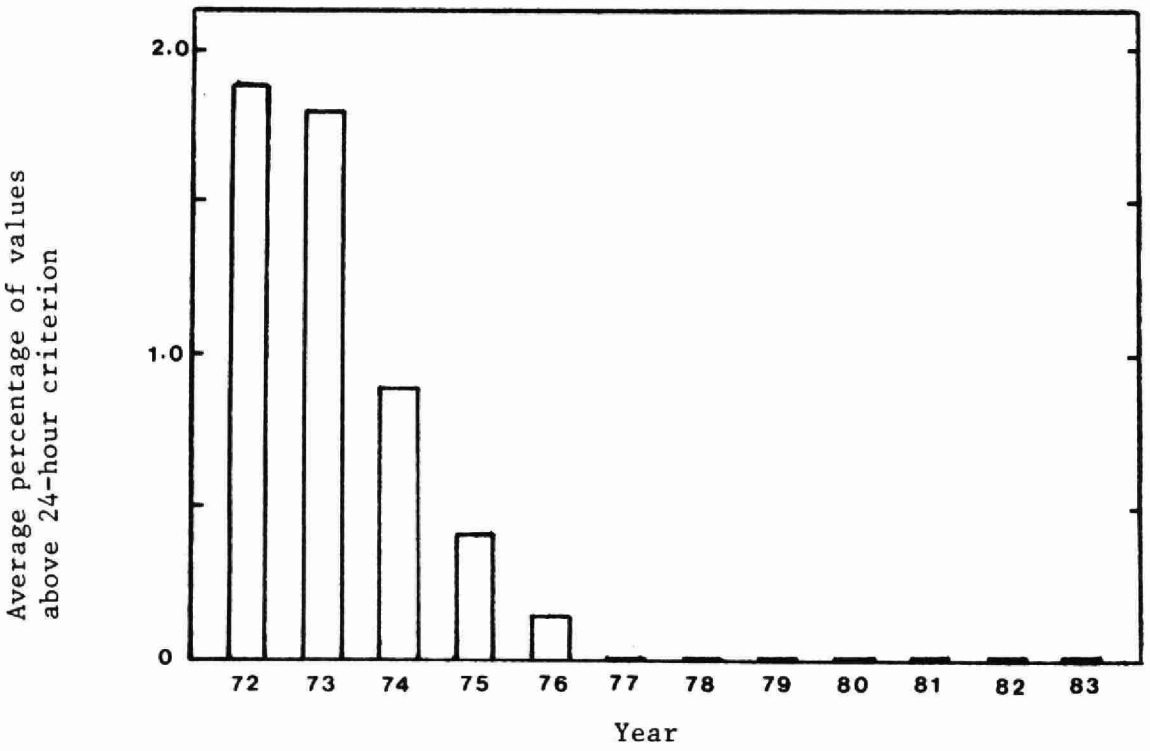
Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide are used to compute 24-hour running averages which are inserted into the following equation:

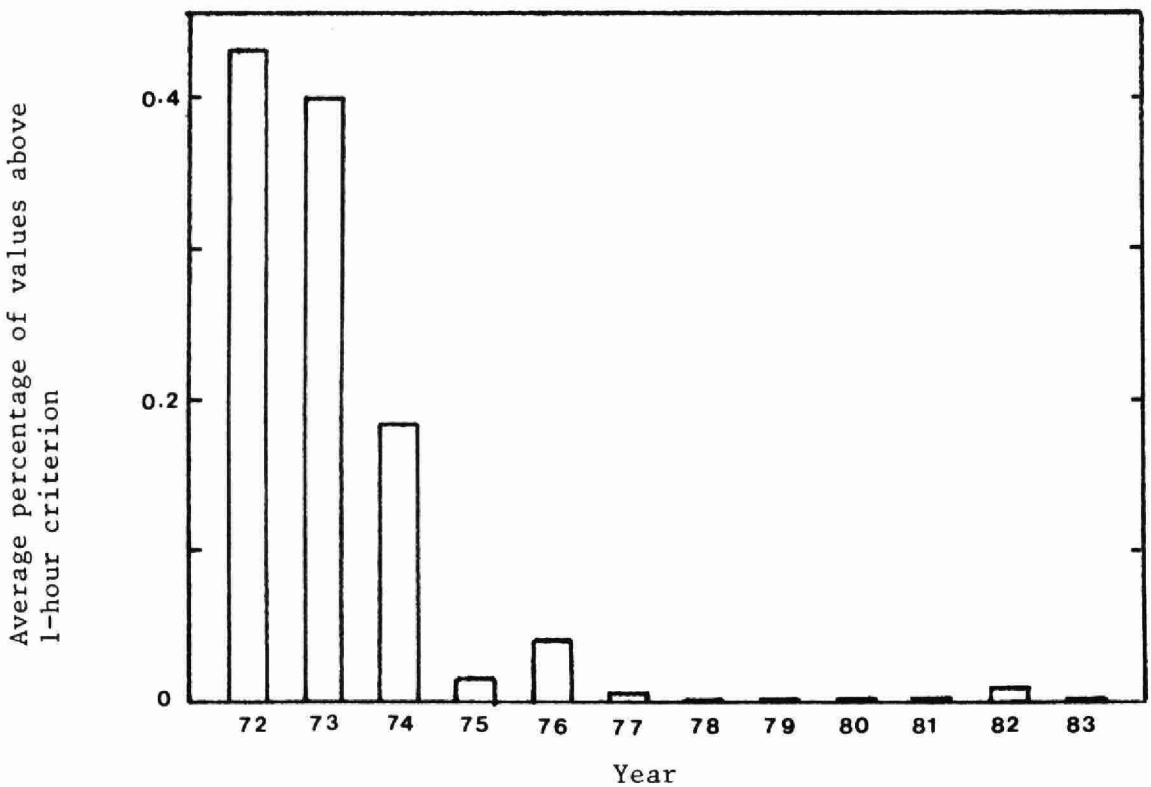
$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million

Figure 4. Trend in frequencies of excursions for sulphur dioxide based on combined data for stations 12008 and 12032.





API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operation. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other pollution generating activities not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at stations 12008 in downtown Windsor, and at station 12016 in west Windsor. At station 12008 the API did not reach the Advisory Level of 32. At midnight on March 1, 1983 the API at station 12016 reached 33 and remained at 33 for a total of 4 hours. The rest of the readings for 1983 were below the Advisory Level. The API levels of 33 were attributable almost entirely to elevated levels of particulates as sulphur dioxide levels were low.

TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds. There are many sources of reduced sulphur compounds including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by reduced sulphur compounds. Probable sources of these odours are the coking operations of the steel industry in Wayne County, Michigan.

The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 parts per

billion (ppb) during a 1-hour period. There is also a criterion for hydrogen sulphide which is 20 ppb during a 1-hour period. These criteria were established on the basis of odour. The instrument used by the Ministry to measure total reduced sulphur compounds in Windsor does not differentiate between hydrogen sulphide and mercaptans. The instrument reports the combined levels of hydrogen sulphide and mercaptans as total reduced sulphur, expressed as hydrogen sulphide. In consideration of the combined levels measured by the instrument, the levels are compared with the less restrictive criterion for hydrogen sulphide.

The total reduced sulphur monitoring is conducted on a continuous basis at station 12032, located in west Windsor near Morton Dock. Of the 8034 concentrations reported for 1983, only 2 exceeded the 1-hour criterion of 20 ppb. The excursions occurred on 2 consecutive hours in August with both values being 27 ppb. A summary of the results appears in Appendix 3, Table A5.

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they are near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 8

years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1972, is presented in Appendix 3, Table A5. Data obtained from 1972 to 1976 are higher than data for the past 7 years. The differences in measured levels are attributed in part to replacement in late 1976 of a less accurate monitoring instrument with a more sophisticated one.

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours (midnight to midnight).

During 1983 the criteria were not exceeded. The 24-hour criterion has not been exceeded at station 12008, located in downtown Windsor, since the chemiluminescence-type monitor was installed in 1974. During the same time period there has been only one excursion above the 1-hour criterion. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be higher at station 12008 than in other

areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A5, Appendix 3.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, more stringent controls for oxides of nitrogen are under consideration.

HYDROCARBONS

The principal man-made source of hydrocarbons is emissions from motor vehicles. Other significant man-made sources are incomplete combustion of fuels by industries and power generating plants, and evaporation losses during manufacture, use, storage and transportation of materials containing volatile hydrocarbons. In the Windsor area, hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of emissions from stationary sources. Natural phenomena produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be

attributable to detrimental compounds. Furthermore, the non-methane hydrocarbons or "reactive" hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at station 12008 in downtown Windsor using flame ionization detection. Levels of total hydrocarbons were similar in 1983 to previous years and no trend of changing levels is apparent. Similarly, the average concentration of reactive hydrocarbons have not demonstrated significant change since monitoring began in 1981. A summary of annual average concentrations appears in Table A5, Appendix 3.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and reactive hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air. The monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful.

Occasionally, ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Incidents of long-range transport from distances greater than 200 kilometres have been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone of 0.12 ppm averaged for 1 hour. Individual states are required to bring ozone levels into compliance with the standard by the end of 1987.

The Ontario criterion for desirable ambient air is 0.08 ppm averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at millions of dollars annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop a suitable control strategy.

Ozone is monitored by a chemiluminescence-type instrument at station 12008, in downtown Windsor. During 1983 there were 116 hourly values reported in excess of the 1-hour criterion, all of which occurred during the months of

May through September. With photochemical formation of ozone being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequency of excursions above the criterion. A summary of ozone data is presented in Appendix 3, Table A5.

Although sufficient meteorological data were unavailable for 1983 to construct a pollution rose for ozone, historical data have shown that the majority of excursions above 0.08 ppm are associated with southerly winds.

Most of the excursions associated with southerly winds are a result of long-range transport of ozone and its precursors. The abatement strategies being developed in the United States should reduce the number and magnitude of excursions attributable to long-range transport.

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power generating plants where coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to a location south of Windsor.

Fluoridation rate is a measurement designed to indicate the relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ugF/100 cm^2/30days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ugF/100 cm^2/30 days applies to the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ugF/100 cm^2/30 days). In recent years, investigations of vegetation have not revealed any appreciable damage to vegetation in Windsor attributable to fluorides.

During 1983 there were seven sites where fluoridation rates were monitored, 4 in west Windsor and 3 in the downtown area. The growing season criterion was marginally exceeded on 3 occasions at stations 12015 and 12016, located in west Windsor. Figure 5 shows that fluoridation rates were higher in west Windsor than in LaSalle or the downtown area during 1983. The 1983 fluoridation rates appear in Table 4.

Fluoridation rate is not considered a sensitive indicator of temporal trends of fluoride levels. However, based on data from six monitoring sites in operation since 1972, the annual average for fluoridation rate and the frequencies of excursions above the criteria for desirable ambient air quality have been lower in recent years with the lowest values experienced in 1982 and 1983. Figure 6 shows the trend towards lower levels of fluoridation rates.

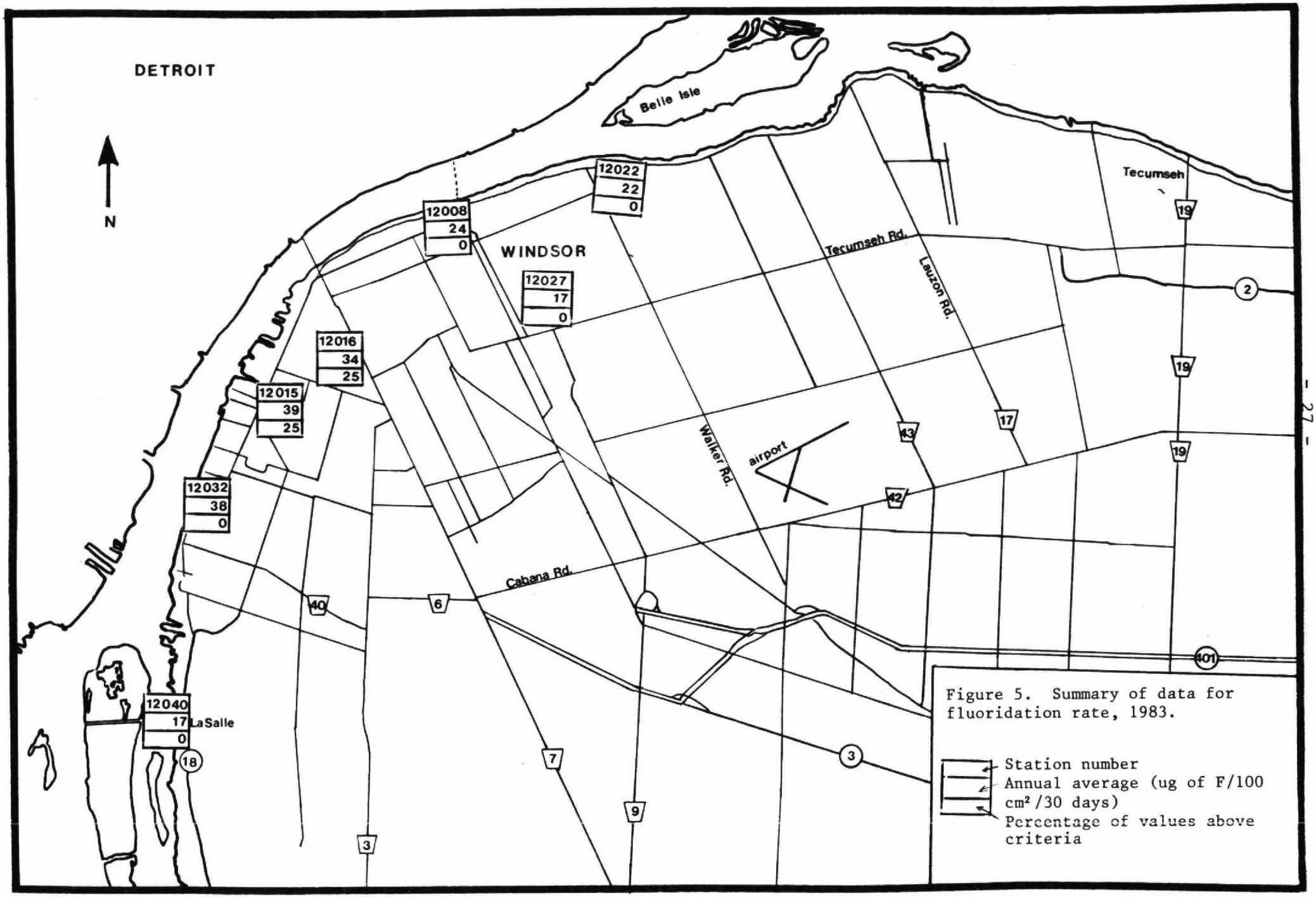


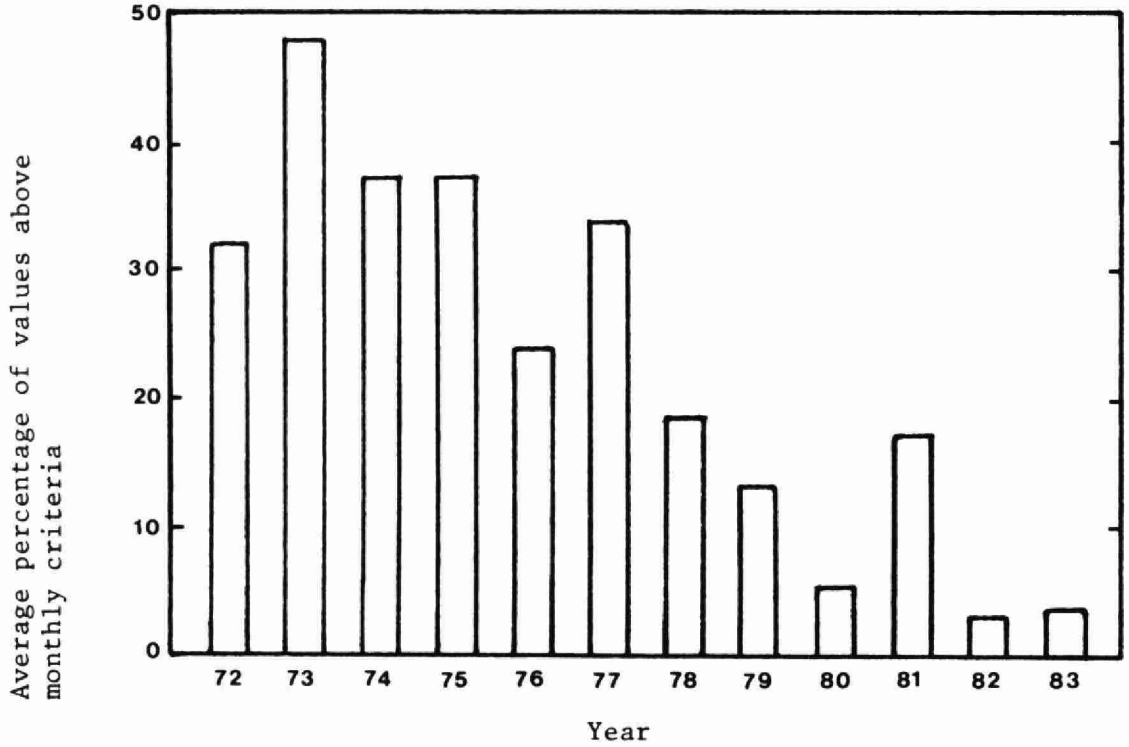
Figure 5. Summary of data for fluoridation rate, 1983.

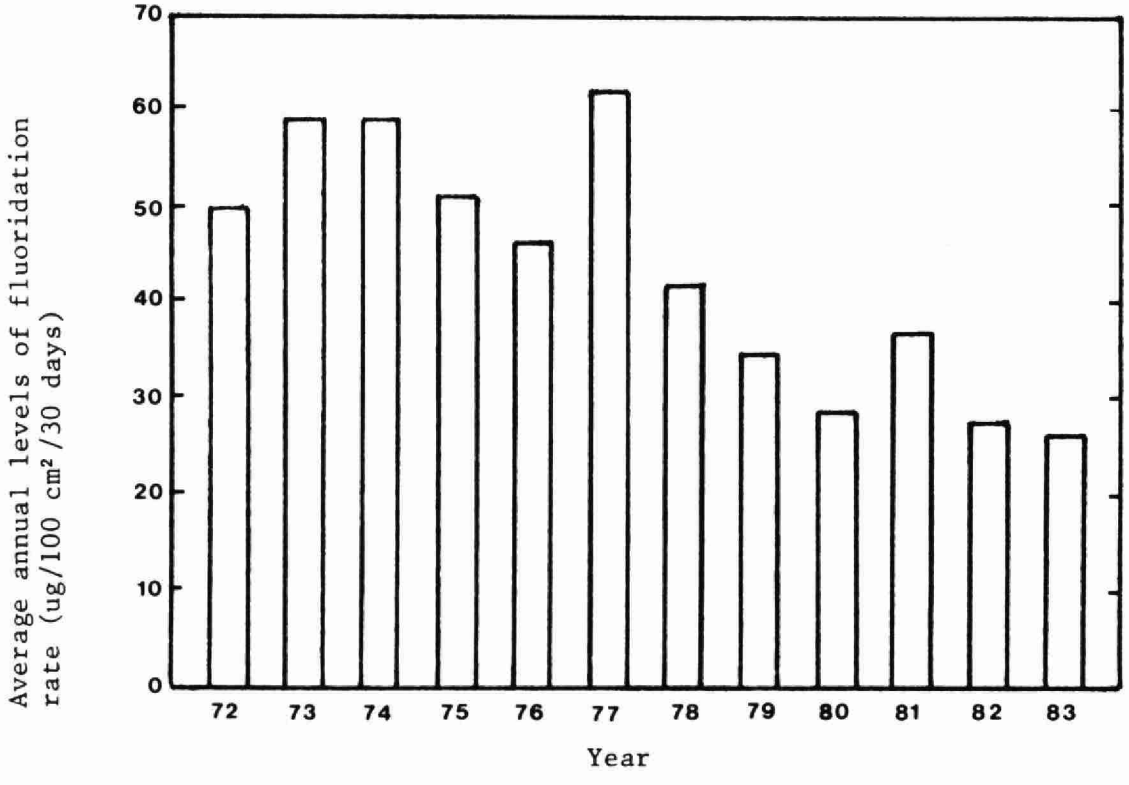
Table 4. Levels of fluoridation rate during 1983

Station Number	Fluoridation rate (ugF/100 cm^2/30 days)												Annual Average	Percentage of values above criteria
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec		
12008	18	23	16	15	18	23	26	30	21	15	41	41	24	0
12015	37	28	23	37	34	41	53	43	40	22	50	63	39	25
12016	22	35	22	20	28	41	46	41	26	22	46	63	34	25
12022	22	23	17	19	17	30	30	30	16	8	22	32	22	0
12027	16	16	11	12	12	25	29	24	13	6	17	26	17	0
12032	33	32	24	39	37	38	37	40	39	25	54	62	38	0
12040	17	16	21	27	11	18	19	21	11	12	14	19	17	0

Note: Underlined values exceed criteria for desirable ambient air quality

Figure 6. Trend in levels of fluoridation rate based on averaged data for six monitoring stations





APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12001	1.1 km NNE of J. C. Keith Generating Station	03276 - 46839	180	18 & 80
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12006	Beach Lane/Hwy. 18 (LaSalle)	03264 - 46778	176	4
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12032	Morton Dock	03271 - 46817	175	4
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12046	Adams/Hwy 18	03264 - 46778	175	5

Table A2. Parameters monitored in the ambient air in Windsor during 1983

Station Number	Air Pollution Index	Carbon Monoxide	Dustfall	Fluoridation Rate	Hydrocarbons	Meteorological Data	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates	Total Reduced Sulphur
12001						X								
12002													X	
12005													X	
12006													X	
12008	X	X		X	X		X	X	X	X	X	X	X	
12009			X										X	
12010			X										X	
12013			X									X	X	
12015				X									X	
12016	X			X							X	X	X	
12022				X										
12027				X										
12032				X								X	X	X
12036													X	
12037													X	
12039													X	
12040			X	X										
12046			X											

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, property and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m^3 averaged for 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour	Protection of human health
	13 ppm averaged for 8 hours	Protection of human health
Dustfall	7 grams/metre^2 in 30 days	Historial and in keeping with other control agencies
	4.6 grams/metre^2 (monthly average in 1 year)	
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Hydrogen Sulphide	0.02 ppm averaged for 1 hour	Protection against offensive odours
Mercaptans	0.01 ppm averaged for 1 hour	Protection against offensive odours
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

APPENDIX 2

PARTICULATES

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12002															
1976	12	0.003	0.010	12	0.007	0.022	12	0.11	0.36	12	3.4	8.2	12	0.7	1.1
1977	20	0.006	0.016	20	0.032	0.062	20	0.16	0.52	20	3.1	8.4	20	0.7	1.3
1978	24	0.007	0.035	24	0.018	0.045	24	0.23	0.62	24	3.1	9.9	56	0.7	1.5
1979	28	0.004	0.020	28	0.009	0.026	28	0.08	0.20	27	2.0	5.9	49	0.5	1.0
1980	23	0.002	0.008	23	0.006	0.015	23	0.06	0.16	23	1.5	3.2	51	0.4	2.1
1981	55	0.003	0.024	55	0.006	0.027	55	0.03	0.20	55	1.8	6.9	58	0.3	2.0
1982	51	0.003	0.014	51	0.007	0.090	51	0.05	0.15	49	1.4	4.2	54	0.3	1.0
1983	33	0.002	0.009	33	0.004	0.016	33	0.06	0.10	33	1.3	3.0	49	0.3	0.9
12005															
1981	59	0.003	0.035	59	0.004	0.030	58	0.05	0.27	59	1.2	13.0	59	0.3	2.6
1982	54	0.005	0.022	53	0.006	0.043	54	0.06	0.67	49	0.7	2.7	54	0.2	1.1
1983	52	0.002	0.010	48	0.002	0.011	52	0.08	0.29	52	0.8	2.5	51	0.2	0.6
12008															
1976	15	0.001	0.003	15	0.012	0.029	15	0.26	0.45	15	3.3	6.9	15	0.7	1.3
1977	18	0.008	0.025	18	0.018	0.074	18	0.42	1.07	18	4.0	11.1	18	0.8	1.7
1978	23	0.004	0.019	23	0.017	0.045	23	1.13	2.55	23	3.1	9.0	23	0.6	1.8
1979	34	0.004	0.023	34	0.008	0.036	34	0.49	1.62	34	1.9	6.3	34	0.4	1.0
1980	24	0.002	0.008	24	0.004	0.012	24	0.38	1.18	25	1.7	4.1	51	0.4	1.1
1981	307	0.003	0.042	307	0.005	0.043	307	0.15	0.82	307	1.6	7.2	316	0.4	2.0
1982	318	0.003	0.027	317	0.005	0.024	319	0.14	0.68	295	1.2	5.4	313	0.3	1.3
1983	328	0.002	0.025	328	0.004	0.015	328	0.29	1.64	328	1.2	5.5	328	0.3	0.9
12009															
1978													53	0.4	1.4
1979													47	0.2	0.8
1980													53	0.2	0.7
1981													43	0.1	0.4
1982													53	0.1	1.0
1983													53	0.2	0.8

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12016															
1978										56	3.8	12.5			
1979										52	3.1	10.1			
1980										52	2.6	6.2			
1981										10	1.7	3.3			
1982										54	1.5	6.3			
1983										73	1.5	4.0			
12032															
1976										40	4.1	8.4	15	0.5	1.3
1977										29	3.5	17.9	26	0.5	0.9
1978										49	3.1	9.6	37	0.4	2.1
1979										43	3.6	9.6	58	0.3	1.4
1980										32	2.3	5.8	33	0.3	0.6
1981										56	1.4	8.2	57	0.2	0.4
1982										54	1.4	6.3	55	0.2	0.8
1983										57	1.7	6.4	57	0.2	0.9
12039															
1978										33	6.3	55.8			
1979										56	3.4	24.6			
1980										54	3.1	37.0			
1981										59	1.8	10.4			
1982										52	1.5	12.4			
1983										58	2.6	14.0			

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12002															
1976	12	0.12	0.22	12	0.013	0.027	54	4.9	11.8	54	9.5	35.1	12	0.02	0.03
1977	20	0.11	0.32	20	0.025	0.073	56	4.9	21.6	56	12.5	35.5	20	0.04	0.14
1978	24	0.14	1.10	24	0.016	0.034	52	6.3	20.5	52	14.1	41.1	24	0.00	0.02
1979	28	0.08	0.20	28	0.009	0.015	49	6.8	17.8	49	13.4	28.4	28	0.00	0.03
1980	23	0.05	0.14	23	0.010	0.026	53	6.6	16.9	53	13.8	55.9	23	0.01	0.01
1981	55	0.06	0.20	55	0.011	0.070	58	7.0	19.4	57	13.1	29.7	12	0.01	0.02
1982	51	0.05	0.11	51	0.007	0.027	45	5.4	15.6	51	11.2	37.4	55	0.01	0.02
1983	33	0.04	0.11	33	0.004	0.020	54	4.8	14.5	54	9.7	27.5	33	0.00	0.01
12005															
1981	50	0.04	0.34	58	0.008	0.085	59	4.9	11.1	58	10.6	28.8	50	0.01	0.03
1982	53	0.03	0.10	54	0.011	0.085	44	4.0	10.1	48	10.5	34.3	54	0.00	0.02
1983	52	0.03	0.11	52	0.004	0.017	52	3.6	11.0	52	9.3	29.6	50	0.00	0.01
12008															
1976	15	0.11	0.28	15	0.051	0.409	105	4.8	21.6	104	10.7	39.7	15	0.17	1.47
1977	18	0.19	0.48	18	0.026	0.084	48	5.2	23.5	48	13.4	34.2	18	0.03	0.10
1978	23	0.12	0.31	23	0.026	0.059	55	5.3	20.5	55	14.3	57.1	23	0.00	0.03
1979	34	0.07	0.22	34	0.010	0.027	58	6.0	15.7	58	13.7	40.5	34	0.00	0.01
1980	24	0.06	0.15	24	0.014	0.049	52	5.5	16.2	52	11.8	31.0	24	0.01	0.01
1981	307	0.06	0.25	296	0.008	0.041	305	4.9	19.8	297	10.4	44.5	307	0.01	0.03
1982	319	0.04	0.23	318	0.007	0.071	267	4.6	17.3	268	10.4	50.5	319	0.01	0.03
1983	328	0.04	0.17	306	0.005	0.084	328	4.0	13.2	328	9.5	41.7	328	0.01	0.02
12009															
1979							24	5.2	13.4	24	11.8	25.4			
1980							55	5.3	17.5	55	11.6	24.6			
1981							43	4.5	13.7	41	10.2	26.4			
1982							53	4.1	12.7	53	10.6	32.4			
1983							55	4.1	12.0	55	9.1	20.3			

Table A4. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12010															
1976	12	0.001	0.006	12	0.008	0.026	12	0.12	0.52	12	1.6	5.2	12	0.4	1.0
1977	20	0.002	0.006	20	0.009	0.029	20	0.08	0.24	20	1.2	5.5	20	0.4	0.9
1978	24	0.002	0.007	24	0.007	0.020	24	0.13	0.44	24	1.0	2.5	24	0.3	1.2
1979	32	0.002	0.005	32	0.003	0.015	32	0.19	0.79	32	0.9	2.1	32	0.2	0.6
1980	23	0.002	0.006	23	0.003	0.007	23	0.09	0.21	24	0.5	1.7	23	0.2	0.7
1981	55	0.002	0.012	55	0.004	0.031	55	0.10	0.50	55	0.9	4.4	55	0.2	0.6
1982	57	0.002	0.005	56	0.002	0.009	57	0.14	0.30	52	0.5	1.8	55	0.2	0.8
1983	33	0.001	0.004	33	0.002	0.009	33	0.10	0.22	33	0.5	1.4	33	0.2	0.5
12013															
1976	17	0.006	0.035	17	0.028	0.113	17	0.15	0.28	22	5.8	21.9	17	0.8	2.0
1977	19	0.007	0.033	19	0.033	0.101	19	0.14	0.35	24	7.2	26.3	19	0.8	1.8
1978	23	0.003	0.012	23	0.032	0.116	23	0.09	0.26	57	6.6	23.1	23	0.5	1.0
1979	22	0.002	0.009	22	0.016	0.055	22	0.13	0.60	56	5.5	29.5	22	0.5	0.9
1980	11	0.001	0.002	11	0.009	0.025	11	0.12	0.37	49	2.6	7.7	11	0.3	0.7
1981	53	0.002	0.011	53	0.008	0.029	53	0.14	0.31	56	1.8	6.4	53	0.3	1.2
1982	56	0.003	0.014	56	0.016	0.089	56	0.24	0.63	53	2.6	8.3	54	0.3	1.3
1983	56	0.002	0.011	56	0.009	0.044	56	0.14	0.34	56	3.2	16.2	56	0.2	0.7
12015															
1978										55	4.0	15.4			
1979										48	3.9	11.3			
1980										52	3.0	8.3			
1981	58	0.004	0.022	57	0.009	0.037	57	0.13	0.29	57	2.5	5.8	57	0.3	1.4
1982	53	0.005	0.074	53	0.008	0.059	53	0.20	3.09	52	2.1	27.1	52	0.2	0.8
1983	57	0.002	0.009	57	0.004	0.020	57	0.15	0.75	57	1.8	6.4	57	0.2	1.0

Table A4. Summary of constituents in suspended particulate matter (ug/m^3)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12010															
1976	12	0.06	0.19	12	0.003	0.021	51	3.6	14.2	51	6.9	31.9	12	0.01	0.01
1977	20	0.04	0.20	20	0.019	0.035	52	4.4	24.5	52	10.3	25.4	20	0.01	0.02
1978	24	0.03	0.09	24	0.008	0.019	55	4.5	25.2	55	11.5	44.1	24	0.00	0.00
1979	32	0.03	0.07	32	0.005	0.011	54	5.1	12.6	54	11.5	30.3	32	0.00	0.02
1980	23	0.02	0.05	23	0.004	0.008	53	4.8	10.8	53	10.8	23.5	23	0.00	0.01
1981	55	0.04	0.42	55	0.004	0.018	58	4.5	14.3	58	11.1	36.4	55	0.00	0.02
1982	56	0.02	0.09	57	0.006	0.018	56	3.1	9.7	56	8.8	19.8	57	0.00	0.05
1983	33	0.02	0.04	33	0.003	0.014	33	3.2	10.3	33	8.2	19.3	33	0.01	0.02
12013															
1976	17	0.38	1.94	17	0.004	0.029	59	4.5	15.0	59	8.3	21.0	17	0.01	0.02
1977	19	0.39	2.02	19	0.031	0.069	54	6.1	32.0	54	13.1	33.6	19	0.02	0.07
1978	23	0.24	0.95	23	0.013	0.058	56	6.6	22.8	56	14.7	48.4	23	0.00	0.03
1979	22	0.15	0.38	22	0.011	0.025	56	7.2	22.9	56	15.0	41.9	22	0.00	0.01
1980	11	0.11	0.47	11	0.007	0.012	54	6.0	19.4	54	13.0	26.9	11	0.01	0.01
1981	53	0.06	0.20	53	0.004	0.017	56	6.3	14.7	56	14.1	33.8	53	0.01	0.02
1982	56	0.15	0.92	56	0.009	0.029	56	4.8	15.4	56	10.9	35.0	56	0.01	0.04
1983	56	0.15	1.14	56	0.006	0.024	32	4.6	12.5	32	9.6	23.4	56	0.00	0.02
12015															
1981	52	0.08	0.22	57	0.008	0.047	55	6.0	17.3	55	14.3	32.3	51	0.01	0.02
1982	52	0.05	0.15	53	0.010	0.102	51	4.6	15.1	51	11.7	28.0	53	0.01	0.13
1983	57	0.06	0.14	57	0.004	0.020	43	4.5	13.8	43	10.8	27.5	57	0.01	0.07
12032															
1981							57	5.5	18.1	55	13.6	29.3			
1982							55	4.4	14.1	55	11.0	32.2			
1983							57	4.5	13.7	57	11.3	26.3			

APPENDIX 3

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Total reduced sulphur												
Annual average (ppb)	0.4	0.1	0.5[a]									
Percentage of values greater than:												
1-hour criterion	0.02	0.01	0.06									
Carbon monoxide												
Annual average (ppm)	1	1	1	2	2	2	2	4	5	5	5	5
Percentage of values greater than:												
1-hour criterion	0	0	0	0	0	0	0	0	0	0.01	0	0
8-hour criterion	0	0	0	0	0	0	0	0	0.32	0.30	0.10	0
Nitrogen dioxide												
Annual average (ppm)	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03		
Percentage of values greater than:												
1-hour criterion	0	0	0	0	0	0.01	0	0	0	0		
24-hour criterion	0	0	0	0	0	0	0	0	0			
Nitric oxide												
Annual average (ppm)	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04		
Total oxides of nitrogen												
Annual average (ppm)	0.04	0.04	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.07		
Total hydrocarbons												
Annual average (ppm)	2.1	2.1	2.1	2.2	1.9[b]	2.3	2.4	2.6	2.2	1.9	2.1	2.2
Reactive hydrocarbons												
Annual average	0.3	0.4	0.4									

Table A5. continued

Parameter	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Ozone												
Annual average (ppm)	0.019	0.018	0.019	0.020	0.016	0.018	0.021	0.021	0.017	0.014		
Percentage of values greater than 1-hour criterion	1.4	0.6	1.3	1.8	0.8	2.4	3.1	2.5	2.2	0.8		

(a) 8 months of data
(b) 9 months of data